

NPS55-77-37

# NAVAL POSTGRADUATE SCHOOL

## Monterey, California



AN INTERACTIVE MODEL TO COMPUTE  
THE OFFICER MANPOWER PLAN  
FOR THE UNITED STATES MARINE CORPS

by

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August 1977

Approved for public release; distribution unlimited.

Prepared for:  
Headquarters Marine Corps  
Code MPI20  
Washington, DC 20380

FEDDOCS  
D 208.14/2:  
NPS-55-77-37

NAVAL POSTGRADUATE SCHOOL  
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This work was supported by the Manpower Planning Division (MPI20) of the Marine Corps through the Navy Personnel Research and Development Lab, San Diego.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NPS55-77-37	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) An Interactive Model to Compute the Officer Manpower Plan for the United States Marine Corps		5. TYPE OF REPORT & PERIOD COVERED Technical Report
7. AUTHOR(s) Kneale T. Marshall		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, CA 93940		8. CONTRACT OR GRANT NUMBER(s)
11. CONTROLLING OFFICE NAME AND ADDRESS Headquarters Marine Corps, Code MPI20 Washington, DC 20380		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS N68221 77 WR 70052
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		12. REPORT DATE August 1977
		13. NUMBER OF PAGES 42
		15. SECURITY CLASS. (of this report) UNCLASSIFIED
16. DISTRIBUTION STATEMENT (of this Report)  Approved for public release; distribution unlimited.		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)  Manpower                      Personnel Forecasting                    Planning		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  This report describes a mathematical model and a set of associated inter- active APL functions which are used to calculate an officer manpower plan for the United States Marine Corps. This plan is used during the budget prepara- tion cycle and represents the future forecasted and planned force structure by rank. A complete plan can be calculated and printed in less than five minutes. This is a considerable reduction from the times involved in hand calculations. This increase in speed allows the planning officers to try		

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## 1. Introduction

This report describes a mathematical model and a set of associated interactive *APL* functions which are used to calculate an officer manpower plan for the United States Marine Corps. This plan is used during the budget preparation cycle and represents the future forecasted and planned force structure by rank.

A complete plan can be calculated and printed in less than five minutes. This is a considerable reduction from the times involved in hand calculations. This increase in speed allows the planning officers to try many alternate plans in a short period of time, and do sensitivity analysis on certain data elements such as loss rates.

A brief summary of the method of calculation is given here. Details are presented in section 3. End strengths (by month) are given for ranks General through Captain, as well as losses and gains to these ranks. From these the monthly numbers of promotions out of ranks Colonel through 1-st Lieutenant are calculated. For ranks Warrant Officer-1 through 2-nd Lieutenant, the numbers of monthly promotions are given, and thus the monthly end-strengths for these ranks are determined. Finally, once promotions into and out of 1-st Lieutenant have been calculated, the monthly end-strengths are calculated for that rank.

Section 2 contains the mathematical formulation of the flow model which is based on ideas presented in chapter 1 of reference [2]. Section 3 gives a detailed description of the order in which the calculations are made. Section 4 describes a set of data input functions written in *APL* and intended for interactive use in entering data. Section 5 describes a set of calculation and format functions written in *APL* and intended for calculation and display of the officer manpower plan. Readers unfamiliar with *APL* should see reference [1]. Finally, section 6 shows a sample use of the functions and displays a plan.

All the functions in this report are in a workspace called *OFFICERPLAN* in the

*APL+* system of Scientific Time Sharing Corporation. They were prepared at the Naval Postgraduate School through constant communication with the staff in MPP at Headquarters, Marine Corps.



## 2. The Personnel Flow Model

In this section is described the mathematical flow model and how it is used to determine the officer manpower plan. The model is based on simple conservation of flow equations (see chapter 1 of reference [2] for details of flow models). Let the discrete planning time (typically the end of each month) be numbered  $t = 0, 1, 2, \dots$ , with  $t = 0$  being the starting point. The time interval between times  $t$  and  $t+1$  we call period  $t+1$ . At each time  $t$  we count the number in each rank and call it the stock level at time  $t$ . People are promoted, join, or leave between the accounting time points, and these are called flows in period  $t$ . Thus we can write

$$(1) \quad \begin{array}{rclclcl} \text{Stock level} & = & \text{Stock level} & + & \text{Gains} & - & \text{Losses} & + & \text{Promotions In} \\ \text{at } (t+1) & & \text{at } t & & \text{in } (t+1) & & \text{in } (t+1) & & \text{in } (t+1) \\ & & & & & & & & \\ & & & & & & & & - \text{Promotions Out} \\ & & & & & & & & \text{in } (t+1) \end{array}$$

To express (1) mathematically we use the following notation. Let

$s_j(t)$  = stock level at time  $t$  in rank  $j$

$g_j(t)$  = gains in period  $t$  into rank  $j$

$\ell_j(t)$  = losses in period  $t$  from rank  $j$

$x_j(t)$  = promotions in period  $t$  into rank  $j$

$y_j(t)$  = promotions in period  $t$  out of rank  $j$

The index  $j$  ranges over  $1, 2, \dots, n$ , where  $n$  is the number of ranks which are numbered in decreasing seniority. Thus rank 1 is the highest rank and rank  $n$  is the lowest. Equation (1) now becomes

$$(2) \quad s_j(t+1) = s_j(t) + g_j(t+1) - \ell_j(t+1) + x_j(t+1) - y_j(t+1),$$

$$j = 1, 2, \dots, n, \quad t \geq 0.$$

Let  $s(t)$ ,  $g(t)$ ,  $\ell(t)$ ,  $x(t)$  and  $y(t)$  represent the  $n$ -dimensional vectors for  $s_j(t)$ ,  $g_j(t)$ ,  $\ell_j(t)$ ,  $x_j(t)$  and  $y_j(t)$  respectively. Then we can write (2) as

$$(3) \quad s(t+1) = s(t) + g(t+1) - \ell(t+1) + x(t+1) - y(t+1), \quad t \geq 0.$$

Before this general model can be applied to the USMC officer corps, further explanation is required of what we precisely mean by ranks, and for each rank, the definition of gains and losses.

In the computer models described later in this report  $n$  has the value 11 and the ranks are:

<u>Number (j)</u>	<u>Rank</u>	
1	General	(GEN)
2	Colonel	(COL)
3	Lieutenant Colonel	(LCOL)
4	Major	(MAJ)
5	Captain	(CAPT)
6	First Lieutenant	(1LT)
7	Second Lieutenant	(2LT)
8	Warrant Officer-4	(CWO-4)
9	Warrant Officer-3	(CWO-3)
10	Warrant Officer-2	(CWO-2)
11	Warrant Officer-1	(WO-1)

For each rank, the sources of gains are:

<u>Rank</u>	<u>Sources of Gains</u>
GEN	None
COL-CAPT	Returns from reimbursable billets
1LT-2LT	Accessions into the commissioned officer corps
CWO-4 - CWO-2	None
WO-1	Accessions into the warrant officer corps

For each rank the sources of losses are:

<u>Rank</u>	<u>Sources of Losses</u>
GEN	Natural attrition and retirement
COL-MAJ	Natural attrition, retirement and movement to reimbursable billets
CAPT	Natural attrition, those released from active duty, and movement to reimbursable billets
1LT	Natural attrition and those released from active duty
2LT - WO-1	Natural attrition

Promotions into a given rank are of course related to promotions out of lower ranks. Since time periods are typically of one-month length, promotions of more than 1 rank in a time period are assumed not to occur. An exception occurs in promotions from warrant officer status to limit duty officer (LDO) in the rank of 1LT.

For the ranks GEN through CAPT and for CWO-4 through CWO-2, the promotions into a rank are equal to the promotions out of the next lower rank. Thus

$$(4) \quad x_j(t) = y_{j+1}(t), \quad j = 1, 2, \dots, 5, \quad t \geq 1. \\ j = 8, 9, 10,$$

Note that  $y_1(t)$  is zero (no promotions out of the highest rank).

Let  $z_j(t)$  be the number in rank  $j$  promoted to 1LT as LDO's, for  $j = 8, 9, 10$ ,  $t \geq 1$ . Then

$$(5) \quad x_6(t) = y_7(t) + z_8(t) + z_9(t) + z_{10}(t), \quad t \geq 1.$$

No promotions are possible into 2LT or WO-1, thus  $x_7(t)$  and  $x_{11}(t)$  are both zero.

Equation (3) can now be simplified by eliminating  $x(t+1)$ . Let  $A$  be an  $11 \times 11$  matrix of 0's and 1's where

(i) the diagonal immediately above the main diagonal has all elements equal to 1 except for the one on row 6 which is 0,

(ii) all other elements of  $A$  are 0.

Let  $B$  be an  $11 \times 11$  matrix of 0's and 1's where

(i) elements in columns 8, 9, and 10 on row 6 are equal to 1,

(ii) all other elements are equal to 0.

Let  $z(t)$  be an  $11$ -vector with  $z_8(t)$ ,  $z_9(t)$  and  $z_{10}(t)$  in positions 8, 9, and 10 respectively, and all other elements equal to zero. Then from (4) and (5)

$$(6) \quad x(t) = Ay(t) + Bz(t), \quad t \geq 1.$$

Substituting this into (3) gives

$$(7) \quad s(t+1) = s(t) + g(t+1) - \lambda(t+1) + (A-I)y(t+1) + Bz(t+1), \quad t \geq 0.$$

Here  $I$  represents an identity matrix. Equation (7) can now be used to determine the officer manpower plan.

### 3. The Calculation Procedure

For ranks GEN through CAPT (1-5) the end strengths, gains and losses are all given. Denote with  $\bar{a}$  the system comprising the first 5 equations in (7). Since the  $5 \times 5$  matrix taken from the upper left of  $B$  is a zero matrix, we have

$$(8) \quad \bar{s}(t+1) = \bar{s}(t) + \bar{g}(t+1) - \bar{\ell}(t+1) + (\bar{A} - \bar{I})\bar{y}(t+1), \quad t \geq 0.$$

The only unknowns in this equation are the elements of  $\bar{y}(t)$  for  $t \geq 1$ . Thus we solve (8) to obtain

$$(9) \quad \bar{y}(t+1) = (I - \bar{A})^{-1} [\bar{s}(t) - \bar{s}(t+1) + \bar{g}(t+1) - \bar{\ell}(t+1)], \quad t \geq 0.$$

The solution of (9) gives the promotions out of ranks COL through 1LT for each period in the planning horizon.

For ranks 2LT to WO-1, the promotions out are given, together with the gains and losses. Denote with  $\hat{a}$  the system comprising the last 5 equations in (7). Then given the starting stocks we determine  $\hat{s}(1)$  by

$$(10) \quad \hat{s}(1) = \hat{s}(0) + \hat{g}(1) - \hat{\ell}(1) + (\hat{A} - I)\hat{y}(1) + \hat{B}\hat{z}(1),$$

then  $\hat{s}(2)$ ,  $\hat{s}(3)$  etc. recursively through the planning horizon. The only remaining rank for which calculations have not been made is 1LT. For ranks above this, end-strengths are given and promotions calculated. For ranks below 1LT, promotions are given and end-strengths calculated. For 1LT we have

$$s_6(t+1) = s_6(t) + g_6(t+1) - \ell_6(t+1) + x_6(t+1) - y_6(t+1), \quad t \geq 0.$$

Starting at  $t = 0$ ,  $s_6(0)$  is given, as are  $g_6(1)$  and  $\ell_6(1)$ . Promotions out,  $y_6(1)$ , are calculated through equation (9), and promotions in,  $x_6(1)$ , are calculated through (10) and (5). Thus the unknown is the end-strength  $s_6(1)$ . This and future period end strengths are calculated recursively over the planning horizon after equations (9) and (10) have been solved for all other ranks.

#### 4. APL Data Input Functions

The following page lists eleven matrices and one vector which are used to store input data required in computing the officer manpower plan. The results of the calculations are also stored in these arrays.

There are eight *APL* input functions used to interactively enter data at a remote terminal. Each one is described on the following pages together with a listing of the function and an illustrative example of its use. Alternative methods of data input are illustrated. The use of the *APL* operator  $\rho$  can save time when repetitive numbers have to be entered. See Gilman and Rose [1] for details of *APL* operators.



## DATA ARRAYS

These arrays are stored as global variables.

<u>APL Name</u>	<u>Dimensions</u>	<u>Description</u>
<u>BSM</u>	11 x 12	Matrix of beginning strengths, 11 ranks (GEN - WO-1), 12 periods
<u>ESM</u>	11 x 12	Matrix of end strengths, 11 ranks, 12 periods
<u>LFM</u>	11 x 12	Matrix of loss factors, 11 ranks, 12 periods
<u>LM</u>	11 x 12	Matrix of losses, 11 ranks, 12 periods
<u>MGM</u>	11 x 12	Matrix of monthly gains, 11 ranks, 12 periods
<u>POM</u>	11 x 12	Matrix of promotions "out", 11 ranks 12 periods
<u>LDM</u>	11 x 12	Matrix of promotions to LDO from warrant officer ranks, 11 ranks, 12 periods
<u>ARM</u>	11 x 12	Matrix of numbers in reimbursable billets, 11 ranks, 12 periods
<u>TRM</u>	11 x 12	Matrix of transfers <u>to</u> reimbursable billets, 11 ranks, 12 periods
<u>FRM</u>	11 x 12	Matrix of transfers <u>from</u> reimbursable billets, 11 ranks, 12 periods
<u>RLM</u>	11 x 12	Matrix of numbers released from active duty, 11 ranks, 12 periods
<u>TLV</u>	11	Vector of yearly losses from each rank, 11 ranks

Type )*SAVE* after data entry completion to ensure that new input data is not lost.

BSINPUT (begin strength input)

Syntax: Niladic, interactively asks for input

Global Variables: It requires the error message EM, the rank vector RANKV, and the data matrix BSM.

Files: None

Functions: None

Purpose: This function allows the user to enter the numbers in each of 11 ranks (GEN - WO-1) at the beginning of a planning period and store them as the first column of an 11 x 12 BSM.

Example:

```
      BSINPUT
BEGIN STRENGTH?
  GEN    COL    LCOL    MAJ    CAPT    1LT    2LT    W-4    W-3    W-2    W-1
□:      67    573    1471    2909    4848    4086    3381    199     79     411    504
```

Function Listing:

```
      ▽BSINPUT[□]▽
▽ BSINPUT;X
[1]  L1:'BEGIN STRENGTH?' ◇ RANKV
[2]   →(11=ρX←□)ρL2 ◇ EM ◇ →L1
[3]  L2:BSM[;1]←X
▽
```

*ESINPUT* (end strength input)

Syntax: Niladic, interactively asks for input

Global Variables: It requires the error message *EM*, the month matrix *MONTH*, the rank vector *RANKV*, and the data matrix *ESM*.

Files: None

Functions: None

Purpose: This function allows the user to enter the planned end strengths for ranks GEN, COL, LCOL, MAJ, and CAPT for each of the 12 planning months. These are stored in the first 5 rows of the 11 x 12 matrix *ESM*.

Example:

```
ESINPUT
END STRENGTH?
GEN
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
 67 67 67 67 67 67 67 67 67 67 67 67
COL
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
 12p574
LCOL
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
 12p1472
MAJ
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
 (5p2910),2912,6p2913
CAPT
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
 12p4848
```

### Function Listing:

```
▽ESINPUT[□]▽
▽ ESINPUT;X
[1] 'END STRENGTH?' ◇ I←0
[2] L1:RANKV[(6×I)+15] ◇ .MONTH,' '
[3] →(12=pX+□)pL2 ◇ EM ◇ →L1
[4] L2:ESM[I+1;]+X ◇ →(4≥I+I+1)pL1
▽
```

LFINPUT (loss factor input)

Syntax: Niladic, interactively asks for input

Global Variables: It requires the error message EM, the month matrix MONTH, the rank vector RANKV and the data matrix LFM.

Files: None

Functions: None

Purpose: This function allows the user to enter the desired loss factors for each of 11 ranks (starting with GEN and ending with W0-1) for each of the 12 planning months. The 12 month factors must add to 1.0. These factors are used to spread yearly losses from each rank by month. They are stored in the 11 x 12 matrix LFM.

Example:

```
      LFINPUT
LOSS FACTORS?
      GEN
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
  .04 .03 .02 .01 .06 .06 .06 .04 .05 .077

INCORRECT INPUT
      GEN
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
  .04 .03 .02 .01 .06 .06 .05 .05 .07 .31 .1 .2
      COL
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
  |
  |
  |
  |

      W-1
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
  .09 .16 .09 .05 .07 .04 .02 .01 .02 .07 .22 .16
```

Function Listing:

```
      V LFINPUT[□] V
V LFINPUT; I; X
[1] 'LOSS FACTORS?' ◇ I+1
[2] L1: RANKV[(6×I-1)+16] ◇ ,MONTH. ' '
[3] →(12=ρX+□)ρL2 ◇ EM ◇ →L1
[4] L2: LFM[I;] ←X ◇ →(11≥I+I+1)ρL1
V
```

MGINPUT (monthly gains input)

Syntax: Niladic, interactively asks for input

Global Variables: It requires the error message EM, the rank vector RANKV, the month matrix MONTH, and the data matrix MGM.

Files: None

Functions: None

Purpose: This function allows the user to enter the expected gains in each of 12 months into the ranks W0-1, 2LT and 1LT respectively. These are stored in rows 11, 7 and 6 of the 11 x 12 matrix MGM.

Example:

```
MGINPUT
MONTHLY GAINS?
W-1
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
  0   0   0   0 250   0   0   0   0   0   0   0
2LT
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
242 152 158 102   0  19 134 173 363 140 288   0
1LT
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
  2   1   3   2   6   0   0   2   0   3   0   5
```

Function Listing:

```
▽MGINPUT[□]▽
▽ MGINPUT;I;M;V;X
[1] ' MONTHLY GAINS?' ◇ I+1 ◇ M+ 3 6 p(60+16),(36+16),30+16 ◇ V+ 11 7
[2] L2:RANKV[.M[I;]] ◇ .MONTH.' '
[3] →(12=pX+□)pL3 ◇ EM ◇ →L2
[4] L3:MGM[V[I;]]+X ◇ →(3≥I+I+1)pL2
▽
```

POINPUT (promotions-out input)

Syntax: Niladic, interactively asks for input

Global Variables: It requires the error message EM, the rank vector RANKV, the month matrix MONTH, and the two data matrices POM and LDM.

Files: None

Functions: None

Purpose: This function allows the user to enter the planned promotions in each of 12 months out of ranks 2LT, and the warrant officers. These are stored in rows 7 through 11 of the 11 x 12 matrix POM. The function then asks for the numbers in each 12 months who became limited duty officers (LDO) from each of the 4 warrant ranks. These numbers are stored in rows 8 through 11 of the 11 x 12 matrix LDM.

Example:

```
POINPUT
PROMOTIONS OUT?
  2LT
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
  0 415 14 194 0 4 115 60 750 331 9 14
  W-4
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
  12p0
  W-3
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
  7 4 0 0 0 0 0 0 39 0 0 0
  W-2
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
  0 0 0 0 66 0 0 0 0 0 0 0
  W-1
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
  (4p0),234,7p0
  TO LDO?
  W-4
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
  0 0 0 0 0 0 0 0 2 0 0 0
  W-3
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
  (8p0),25,(3p0)
```



W-2  
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP  
□: (8p0),73,3p0

W-1  
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP  
□: 12p0

# Function Listing:

```

VPOINPUT[□]▽
▽ POINPUT;I;M;X
[1] 'PROMOTIONS OUT?' ◇ I+1
[2] L1:RANKV[(30+I×6)+16] ◇ ,MONTH,' '
[3] →(12=pX+□)pL2 ◇ EM ◇ →L1
[4] L2:POM[I+6;]+X ◇ →(5≥I+I+1)pL1 ◇ I+1 ◇ ' TO LDO?'
[5] L3:RANKV[(36+I×6)+16] ◇ ,MONTH,' '
[6] →(12=pX+□)pL4 ◇ EM ◇ →L3
[7] L4:LDOM[I+7;]+X ◇ →(4≥I+I+1)pL3
▽

```

REIMINPUT (reimbursable input)

Syntax: Niladic, interactively asks for input

Global Variables: It requires the error message EM, the rank vector RANKV, the month matrix MONTH, and the data matrices TRM and FRM.

Files: None

Functions: None

Purpose: This function allows the user to enter scores to and from reimbursable billets for each of 12 months for the ranks COL, LCOL, MAJ, and CAPT and store them in rows 2 through 5 of the 11 x 12 matrices TRM and FRM respectively.

Example:

```
REIMINPUT
COL TO REIMB
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
  1      1 .10p0
COL FROM REIMB
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
  1.11p0
LCOL TO REIMB
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
  |
  |
  |
  |
  |
  |
  |
VALUE ERROR
□      12p0
      ^
□:      12p0
CAPT TO REIMB
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
  2      0      0      0      1      0      0      0      0      0      0      00
CAPT FROM REIMB
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
  1      0      1      0      0      0      0      2      0      0      0      0
```

## Function Listing:

```
    ∇ REIMINPUT[ ] ∇  
  ∇ REIMINPUT; M; X; I  
[1]  M ← 4 6 p6 + 30 + RANKV ◇ I + 1  
[2]  L1: M[I; ], ' TO REIMB' ◇ .MONTH. ' '  
[3]  → (12 = pX + ) pL2 ◇ EM ◇ → L1  
[4]  L2: TRM[I + 1; ] ← X  
[5]  L3: M[I; ], ' FROM REIMB' ◇ .MONTH. ' '  
[6]  → (12 = pX + ) pL4 ◇ EM ◇ → L3  
[7]  L4: FRM[I + 1; ] ← X  
[8]  → (4 ≥ I + I + 1) pL1  
  ∇
```

RLDINPUT (released from active duty input)

Syntax: Niladic, interactively asks for input

Global Variables: It requires the error message EM, the rank vector RANKV, the month matrix MONTH, and the data matrix RLM.

Files: None

Functions: None

Purpose: This function allows the user to enter the numbers in each of 12 months who will be released from active duty in the ranks CAPT and 1LT. The data is stored in rows 5 and 6 of the 11 x 12 matrix RLM.

Example:

```
      RLDINPUT
RELAD?
  CAPT
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
   4  16  14  6   2   9   4   7   9   8  14 12
    1LT
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
□:
  55  55  90  41  35  62  28  48  90  48  62  76
```

Function Listing:

```
      VRLDINPUT[□]V
V RLDINPUT;I;M;V;X
[1] 'RELAD?' ◇ I+1 ◇ M← 2 6 p(24+16),(30+16) ◇ V← 5 6
[2] L1:RANKV[.M[I;]] ◇ ,MONTH.' '
[3] →(12=pX+□)pL2 ◇ EM ◇ →L1
[4] L2:RLM[V[I];]←X ◇ →(2≥I+I+1)pL1
V
```

TLINPUT (total loss input)

Syntax: Niladic, interactively asks for input

Global Variables: It requires the error message EM, the rank vector RANKV, and the data vector TLV.

Files: None

Functions: None

Purpose: This function allows the user to enter the losses from each of the 11 ranks for the planning period, and store them in the 11-vector TLV.

Example:

```
      TLINPUT
TOTAL YEAR LOSSES?
  GEN   COL   LCOL   MAJ   CAPT   1LT   2LT   W-4   W-3   W-2   W-1
□:
    11    95    155    160    593    109    35    60    25    8     4
```

Function Listing:

```
      ∇ TLINPUT[□] ∇
∇ TLINPUT
[1] L1: ' TOTAL YEAR LOSSES?' ∇ RANKV
[2] →(11=ρTLV+□)ρ0 ∇ EM ∇ →L1
∇
```

## 5. APL Calculation and Output Format Functions

The calculation, interactive changing, and formatting of the officer manpower plan require ten *APL* functions. These are listed on the following pages. Only one is specified by the user, namely *OFPLAN*. This function calls the other nine at appropriate points and they remain invisible to the terminal user.



OFPLAN (officer manpower plan)

Syntax: Niladic, interactively asks for various changes in variables and for the amount of detail to be printed.

Global Variables: The data arrays: BSM, ESM, LFM, MGM, POM, LDOM, TRM, FRM, RLM, and TLV.

Files: None

Functions: Requires the utilities AYN (answer yes or no) and DATE, the formatting functions FMTI, ESREP, OF1E, OMPREP and ATREIMB, and the calculation functions CHGFM, CHGIM, PLAN1.

Purpose: This is the main interactive function for obtaining the manpower plan. It is the only one (other than functions to input data) that the user specifies when calculating a plan.

Function Listing: See next page.

```

VOFPLAN[ ]V
V OFPLAN
[1] L5:→(~AYN 'DISPLAY LOSS FACTORS?')pL1 ◇ FMTF LFM
[2] L1:→(~AYN 'CHANGE LOSS FACTORS?')pL2 ◇ LFM←CHGFM LFM
[3] L2:→(~AYN 'DISPLAY END STRENGTHS?')pL3 ◇ FMTI 5 12 +ESM
[4] L3:→(~AYN 'CHANGE END STRENGTHS?')pL7 ◇ ESM←CHGIM ESM
[5] L7:→(~AYN 'CHANGE REIMB?')pL4 ◇ 'TO REIMB' ◇ TRM←CHGIM TRM ◇ 'FROM REIMB' ◇ FRM←CHGIM FRM
[6] L4:PLAN1 ◇ LF
[7] ' USMC OFFICER PLAN DATE:-',DATE ◇ 2pLF
[8] ' MONTHLY END STRENGTHS' ◇ LF ◇ ESREP ◇ 5pLF ◇ →(~AYN '1-E TABLE?')pL6
[9] ' OFFICER 1-E' ◇ LF ◇ OF1E ◇ 5pLF ◇ →(~AYN 'MP PLAN?')pL6
[10] ' OFFICER MANPOWER PLAN ' ◇ OMPREP ◇ 2pLF ◇ ATREIMB
[11] L6:→(AYN 'CONTINUE?')pL5
V

```

## CHGFM

### CHGFM

Syntax: Monadic,  $R \leftarrow \text{CHGFM } M$

Global Variables: It requires the error message EM.

Files: None

Functions: None

Purpose: It allows the user to change any elements in a fractional matrix, and checks that the new entries are consistent with row sums equal to 1.0. It is used only inside other functions.

### Function Listing:

```

      ∇CHGFM[□]∇
      ∇ R←CHGFM M;X;Y
[1]   'ENTER ZERO FOR RANK IF NO MORE CHANGES'
[2]   L1:'RANK NUMBER?' ◇ →(0=X+□)ρL6 ◇ →(11≥X)ρL2 ◇ EM ◇ →L1
[3]   L2:'CURRENT' ◇ , 'F6.2' □ FMT M[X;]
[4]   L3:'NEW?' ◇ →(1=+/Y←□)ρL4 ◇ 'DO NOT ADD TO 1.0' ◇ →L3
[5]   L4:→(12=ρY)ρL5 ◇ 'NEED 12 NUMBERS' ◇ →L3
[6]   L5:M[X;]+Y ◇ →L1
[7]   L6:R←M
      ∇
```

## CHGIM

Syntax: Monadic,  $R \leftarrow CHGIM\ M$

Global Variables: It requires the error message, EM.

Files: None

Functions: None

Purpose: It allows the user to change any elements in an integer matrix. It is used only inside other functions.

Function Listing:

```

      VCHGIM[ ]V
      V R←CHGIM M;X;Y
[1]   'ENTER ZERO FOR RANK IF NO MORE CHANGES'
[2]   L1:'RANK NUMBER?' ◇ →(0=X+ )ρL6 ◇ →(11≥X)ρL2 ◇ EM ◇ →L1
[3]   L2:'CURRENT' ◇ , 'I6' □FMT M[X;]
[4]   'NEW?' ◇ →(12=ρY+ )ρL4 ◇ 'NEED 12 NUMBERS' ◇ →L3
[5]   L4:M[X;]+Y ◇ →L1
[6]   L6:R+M
      V
```

## PLAN1

Syntax: Niladic

Global Variables: It requires all the data arrays, *BSM*, *ESM*, *LFM*, *LM*, *MGM*, *POM*, *LDO1*, *TRM*, *FRM*, *RLM*, and *TLV*.

Files: None

Functions: Requires the integer rounding function *ROUND*

Purpose: This function performs all the calculations for the manpower plan discussed in section 3.

Function Listing: See next page for both *PLAN1* and *ROUND*.

```

[1]  $\forall PLAN1[IV; I; V; PEM; NEM; LM; EV$ 
[2]  $LM \leftarrow ROUND \quad LEM \times Q \quad 12 \quad 11 \quad \rho TLV$ 
[3]  $BSM[IV; 1+11] \leftarrow ESM[IV; 15; 111]$ 
[4]  $POM[1+IV; ] \leftarrow B+ \cdot \times ESM[IV; ] + LM[IV; ] + BSM[IV; ] + BSM[IV; ] + FERM[IV; ] \sim TRM[IV; ]$ 
[5]  $BSM[6; 1+11] \leftarrow 11 + ESM[6; 1] \times (12 + BSM[6; 1]) + MGM[6; 1] + POM[6; 1] + RLM[6; 1] + LLM[6; 1]$ 
[6]  $M \leftarrow 5 \quad 12 \quad + MGM + ((12 \rho 1) \ominus POM) \sim RLM + LM + POM + LDOM$ 
[7]  $E \leftarrow BSM[6+IV; 1] \diamond I \leftarrow 1$ 
[8]  $L1: ESM[6+IV; I] \leftarrow E + M[; I]$ 
 $\rightarrow (12 \geq I + 1) \rho L1 \diamond BSM[6+IV; 1+11] + ESM[6+IV; 111]$ 
 $\nabla$ 

[1]  $\nabla ROUND[\square] \nabla$ 
[2]  $\nabla R \leftarrow ROUND \quad M; EV; TM; N$ 
 $N \leftarrow \rho EV \leftarrow (+/M) \sim +/TM \leftarrow [0.5+M \diamond I \leftarrow 1$ 
 $L1: TM[I; J] \leftarrow TM[I; J \leftarrow 1 + TM[I; ] + EV[I] \diamond \rightarrow (N \geq I + 1) \rho L1 \diamond R \leftarrow TM$ 
 $\nabla$ 

```



## FMTF

Syntax: Monadic,  $R \leftarrow FMTF\ M$

Global Variables: It requires the month matrix MONTH and the rank vector RANKV.

Files: None

Functions: None

Purpose: It formats the fractional matrix M with column and row headers. It is used only within other functions.

Function Listing:

```

      ∇ FMTF[□] ∇
      ∇ FMTF M
[1]   ' RANK',,(12 3 ρ' '),MONTH
[2]   (11 6 ρRANKV),'F6.2' □FMT M
      ∇
```

### FMTI

**Syntax:** Monadic,  $R \leftarrow FMTI\ M$

**Global Variables:** It requires the month matrix MONTH and the rank vector RANKV.

**Files:** None

**Functions:** None

**Purpose:** It formats the matrix  $M$  into integers with column and row headers. It is used only within other functions.

**Function Listing:**

```

      ∇ FMTI[[]]∇
      ∇ FMTI M;N
[1]   N←(ρM)[1]
[2]   ' RANK'.,(12 3 ρ' '),MONTH
[3]   ((N,6)ρRANKV),'BI6' □FMT M
      ∇
```

## ESREP

Syntax: Niladic

Global Variables: It requires the month matrix MONTH, the rank vector RANKV, and the data arrays BSM and ESM.

Files: None

Functions: None

Purpose: It formats the "End Strength Report" as part of the manpower plan.

### Function Listing:

```
      VESREP[ ]V
V ESREP;MYA;X
[1] MYA+(/BSM+ESM)÷24
[2] ' BEGIN', ' GRADE', (, (12 3 p' '), MONTH), ' MYA'
[3] ('I6' FMT 11 1 +BSM), (11 6 pRANKV), 'I6' FMT(ESM), MYA
[4] ' TOTAL', , 'I6' FMT+ESM
V
```

## OF1E

Syntax: Niladic

Global Variables: It requires the month matrix MONTH and the data arrays BSM, ESM, RLM, and LM.

Files: None

Functions: None

Purpose: It formats the "Officer 1E Table" as part of the manpower plan.

### Function Listing:

```

      ▽OF1E[ ] ▽
  ▽ OF1E;X;Y;M;V
[1]  V++M+Q 6 12 ρ(+BSM),X,Y,((Y++LM)+X++RLM),(+MGM),+ESM
[2]  '          !          LOSSES          |'
[3]  'MONTH      BEGIN      RELAD      OTHER      TOTAL      GAINS      END'
[4]  (' ',MONTH, ' '), (12 2 ρ' '), 'BI8' □FMT M
[5]  'TOTAL ' , 'I8' □FMT(M[1;1],(4+1+V),M[12;6])
      ▽
```

OMPREP

Syntax: Niladic

Global Variables: It requires the month matrix *MONTH*, rank vector *RANKV*, the formatting headers *H1*, *H1G*, *H2*, *H3*, *H4*, *H5*, *H6*, *H7*, *H8*, *H9*, *H10*, *H11*, *H12*, *H13*, and *H14*, the line feed *LF*, and all the data arrays.

Files: None

Functions: None

Purpose: It formats the "Officer Manpower Plan," the main output showing the monthly details of a yearly plan for each rank.

Function Listing: See next page.

VOMPREP[ ] V  
V OMPREP; M; V; PI; TL; R; L; OL; G  
' RANK TOTAL', (12 3 p' '), MONTH  
M←BSM[1], BSM, (+/TRM), TRM, (+/LM), LM, (+/PI), (PI←(12p1)◊POM), (+/ERM), ERM,  
ESM[12], ESM  
(4 6 p(12p' '), 6+RANKV), (4 3 p' '), H1G, 'BI6' ◊FMT M1←(1 0 1 0 1 0 1)/[1] 7 13 pM ◊ LF  
(7 6 p(18p' '), 6+6+RANKV), (7 3 p' '), H1, 'BI6' ◊FMT M2← 7 13 pM[2;] ◊ LF  
(7 6 p(18p' '), 6+12+RANKV), (7 3 p' '), H1, 'BI6' ◊FMT M3← 7 13 pM[3;] ◊ LF  
(7 6 p(18p' '), 6+18+RANKV), (7 3 p' '), H1, 'BI6' ◊FMT M4← 7 13 pM[4;] ◊ LF  
TL←(R←(+/R), R←RLM[5;]) + L←13+26+V←M[5;]  
(9 6 p(24p' '), 6+24+RANKV), (9 3 p' '), H2, 'BI6' ◊FMT M5← 9 13 p(26+V), R, L, TL,  
-52+V ◊ LF  
M←(IN, OUT, (39pIN), (OUT←13p0), (IN←13p1))/M  
TL←(R←(+/R), R←RLM[6;]) + OL←13+13+V←M[6;]  
M6← 9 13 p(13+V), R, OL, TL, ((+/G), G←MGm[6;]), (-26+13+V), ((+/L), L←+LDOM), -13+V  
(9 6 p(24p' '), 6+30+RANKV), (9 3 p' '), H3, 'BI6' ◊FMT M6 ◊ LF  
(5 6 p(12p' '), 6+36+RANKV), (5 3 p' '), H4, 'BI6' ◊FMT M7← 5 13 p(26+V), (G←(+/G), G←MGm[  
7;]), (-13+26+V), -13+V←M[7;] ◊ LF  
TO1← 1 13 pM1[1;] + M2[1;] + M3[1;] + M4[1;] + M5[1;] + M6[1;] + M7[1;]  
TO1←TO1, [1] M2[2;] + M3[2;] + M4[2;] + M5[2;]  
TO1←TO1, [1] M1[2;] + M2[3;] + M3[3;] + M4[3;] + M5[5;] + M6[4;] + M7[2;]  
TO1←TO1, [1] M6[5;] + M7[3;] ◊ TO1←TO1, [1] M6[8;]  
TO1←TO1, [1] M2[4;] + M3[4;] + M4[4;] + M5[6;] + M6[6;] + M7[4;]  
TO1←TO1, [1] M1[3;] + M2[5;] + M3[5;] + M4[5;] + M5[7;] + M6[7;]  
TO1←TO1, [1] M2[6;] + M3[6;] + M4[6;] + M5[8;]  
TO1←TO1, [1] M1[4;] + M2[7;] + M3[7;] + M4[7;] + M5[9;] + M6[9;] + M7[5;]  
H5, H6, 'BI6' ◊FMT TO1 ◊ LF  
(5 9 p45+(18p' '), 'CWO-4'), H7, 'BI6' ◊FMT M8← 5 13 p(26+V), (-13+13+V), ((+/L), L←LDOM[  
8;]), -13+V←M[8;] ◊ LF  
H9, (12 12 pH8), 'BI6' ◊FMT M9← 12 13 p(0 -13 +V), ((+/L), L←LDOM[8+12;]), 2 -13 +V←M[  
8+12;] ◊ LF  
M10← 6 13 p(26+V), ((+/G), G←MGm[11;]), (-13+26+V), ((+/L), L←LDOM[11;]), -13+V←M[  
11;]  
(6 9 p54+(18p' '), 'WO-1'), H10, 'BI6' ◊FMT M10 ◊ LF  
TW←(M10[1 2 ;] + M8[1 2 ;] + M9[7 8 ;] + M9[1 2 ;]), [1] M10[3;] ◊ TW←TW, [1] M8[4;] + M10[  
5;] + M9[5 11 ;]  
TW←TW, [1] M10[4;] + M9[3 9 ;] ◊ TW←TW, [1] M8[3;] + M9[4 10 ;] ◊ TW←TW, [1] M8[  
5;] + M10[6;] + M9[6 12 ;]  
H12, H11, 'BI6' ◊FMT TW ◊ LF ◊ H14, H13, 'BI6' ◊FMT TO←TO1[1 2 3 4 8 9 ;] + (1 0 1 1 0 1) \ [  
1] TW[1 2 3 7 ;]

V

## ATREIMB

Syntax: Niladic

Global Variables: It requires the data arrays *ARM*, *TRM* and *FRM*.

Files: None

Functions: None

Purpose: It formats the movement of officers at, to, and from reimbursable billets as part of the manpower plan.

### Function Listing:

```
∇ATREIMB[ ]∇
  ∇ ATREIMB
[1]  '          OFFICERS IN REIMBURSABLE BILLETS'
[2]  '          COL          LCOL          MAJ          CAPT'
[3]  'BEGIN',, 'I10'  □FMT, ARM[1+14;1]
[4]  '  TO',, 'I10'  □FMT(+/TRM)[1+14]
[5]  ' FROM',, 'I10'  □FMT(+/FRM)[1+14]
[6]  '  END',, 'I10'  □FMT(+/TRM+ARM~FRM)[1+14]
  ∇
```



## 6. An Example

The next seven pages give an example of an officer manpower plan. This example does not show every feature of the interactive capability, but should be sufficient to illustrate the use of the model. A complete plan takes less than five minutes of terminal time and less than 1 second CPU time on Scientific Time Sharing's *APL+* system. Thus many iterations are possible in the planning cycle.

OFPLAN

DISPLAY LOSS FACTORS? YES

RANK	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
GEN	0.04	0.03	0.02	0.01	0.06	0.06	0.05	0.05	0.07	0.31	0.10	0.20
COL	0.07	0.05	0.03	0.05	0.07	0.05	0.04	0.05	0.08	0.25	0.14	0.12
LCOL	0.10	0.06	0.04	0.05	0.08	0.06	0.05	0.05	0.06	0.18	0.14	0.13
MAJ	0.08	0.06	0.05	0.07	0.07	0.05	0.06	0.05	0.10	0.16	0.14	0.11
CAPT	0.07	0.07	0.13	0.07	0.06	0.11	0.07	0.07	0.08	0.09	0.09	0.09
1LT	0.08	0.08	0.13	0.06	0.05	0.09	0.04	0.07	0.13	0.07	0.09	0.11
2LT	0.08	0.08	0.08	0.07	0.05	0.09	0.08	0.10	0.10	0.08	0.11	0.08
W-4	0.05	0.05	0.07	0.08	0.08	0.09	0.07	0.10	0.07	0.08	0.10	0.16
W-3	0.11	0.06	0.07	0.07	0.10	0.08	0.07	0.06	0.08	0.10	0.08	0.12
W-2	0.09	0.05	0.16	0.06	0.05	0.13	0.08	0.02	0.04	0.12	0.11	0.09
W-1	0.09	0.16	0.09	0.05	0.07	0.04	0.02	0.01	0.02	0.07	0.22	0.16

CHANGE LOSS FACTORS? NO  
 DISPLAY END STRENGTHS? YES

RANK	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
GEN	67	67	67	67	67	67	67	67	67	67	67	67
COL	574	575	575	574	574	574	574	574	574	574	574	574
LCOL	1472	1472	1472	1472	1472	1472	1472	1472	1472	1472	1472	1472
MAJ	2910	2910	2910	2910	2910	2910	2910	2910	2910	2910	2910	2910
CAPT	4848	4848	4848	4848	4848	4848	4848	4848	4848	4848	4848	4848

CHANGE END STRENGTHS? YES  
 ENTER ZERO FOR RANK IF NO MORE CHANGES

RANK NUMBER?

□:

2

CURRENT

574 575 575 574 574 574 574

NEW?

□:

574 743 575

574 575,90574

RANK NUMBER?

□:

0

CHANGE REIMB? NO

## USMC OFFICER PLAN

DATE: -20 AUGUST 1977

## MONTHLY END STRENGTHS

BEGIN	GRADE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	MYA
67	GEN	67	67	67	67	67	67	67	67	67	67	67	67	67
573	COL	574	574	575	574	574	574	574	574	574	574	574	574	574
1471	LCOL	1472	1472	1472	1472	1472	1472	1472	1472	1472	1472	1472	1472	1472
2909	MAJ	2910	2910	2910	2910	2910	2910	2910	2910	2910	2910	2910	2910	2910
4848	CAPT	4848	4848	4848	4848	4848	4848	4848	4848	4848	4848	4848	4848	4848
4086	1LT	3942	4212	4018	4095	3992	3827	3841	3776	4432	4571	4383	4198	4103
3381	2LT	3620	3354	3495	3401	3399	3411	3427	3543	3152	2958	3233	3216	3358
199	W-4	203	204	200	195	190	185	181	175	208	203	197	187	195
79	W-3	72	66	64	62	125	123	121	119	53	50	48	45	80
401	W-2	399	399	398	398	566	565	564	564	491	490	489	488	481
504	W-1	504	502	502	502	518	518	518	518	518	518	517	516	512
TOTAL		18611	18608	18549	18524	18661	18500	18523	18566	18725	18661	18738	18521	

1-E TABLE? YES

OFFICER 1-E

MONTH	BEGIN	LOSSES		TOTAL	GAINS	END
		RELAD	OTHER			
OCT	18518	59	95	154	244	18611
NOV	18611	71	85	156	153	18608
DEC	18608	104	116	220	161	18549
JAN	18549	47	82	129	104	18524
FEB	18524	37	82	119	256	18661
MAR	18661	71	109	180	19	18500
APR	18500	32	79	111	134	18523
MAY	18523	55	82	137	180	18566
JUN	18566	99	105	204	363	18725
JUL	18725	56	151	207	143	18661
AUG	18661	76	135	211	288	18738
SEP	18738	88	134	222	5	18521
TOTAL	18518	795	1255	2050	2050	18521

MP PLAN? YES

RANK	OFFICER MANPOWER PLAN												
	TOTAL	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
GEN	BEGIN	67	67	67	67	67	67	67	67	67	67	67	67
	LOSSES	11				1	1	1	1	1	3	1	2
	PROM IN	11				1	1	1	1	1	3	1	2
	END	67	67	67	67	67	67	67	67	67	67	67	67
COL	BEGIN	573	573	574	574	575	574	574	574	574	574	574	574
	TO REIMB												
	LOSSES	95	7	5	3	5	7	4	5	8	22	13	11
	PROM OUT	11					1	1	1	1	3	1	2
LCOL	PROM IN	106	7	5	4	4	8	5	6	9	25	14	13
	FROM REIMB	1	1										
	END	574	574	574	575	574	574	574	574	574	574	574	574
	TO REIMB												
MAJ	BEGIN	1471	1471	1472	1472	1472	1472	1472	1472	1472	1472	1472	1472
	LOSSES	155	16	9	6	8	12	8	8	9	28	22	20
	PROM OUT	106	7	5	4	4	8	5	6	9	25	14	13
	PROM IN	261	23	14	10	12	20	13	14	18	53	36	33
MAJ	FROM REIMB	1	1										
	END	1472	1472	1472	1472	1472	1472	1472	1472	1472	1472	1472	1472
	TO REIMB												
	LOSSES	160	13	10	8	11	11	10	8	16	25	22	18
MAJ	PROM OUT	261	23	14	10	12	20	13	14	18	53	36	33
	PROM IN	421	36	24	18	23	31	23	22	34	78	58	51
	FROM REIMB	1	1										
	END	2910	2910	2910	2910	2910	2910	2910	2910	2910	2910	2910	2910

BEGIN	4848	4848	4848	4848	4848	4848	4848	4848	4848	4848	4848	4848
TO REIMB												
RELAD	105	4	16	14	6	2	9	4	7	9	8	14
OTHER LOSSES	593	42	42	76	42	36	65	42	42	47	53	53
TOTAL LOSSES	698	46	58	90	48	38	74	46	49	56	61	67
PROM OUT	421	36	24	18	23	31	23	23	22	34	78	58
PROM IN	1119	82	82	108	71	69	97	69	71	90	139	125
FROM REIMB												116
END	4848	4848	4848	4848	4848	4848	4848	4848	4848	4848	4848	4848

CAPT

BEGIN	4086	4086	3942	4212	4018	4095	3992	3827	3841	3776	4432	4571	4383
RELAD	690	55	55	90	41	35	62	28	48	90	48	62	76
OTHER LOSSES	109	9	9	13	7	5	10	4	8	14	8	10	12
TOTAL LOSSES	799	64	64	103	48	40	72	32	56	104	56	72	88
GAINS	24	2	1	3	2	6			2		3		5
PROM OUT	1119	82	82	108	71	69	97	69	71	90	139	125	116
PROM IN	1906		415	14	194		4	115	60	750	331	9	14
FROM W.O.	100									100			
END	4198	3942	4212	4018	4095	3992	3827	3841	3776	4432	4571	4383	4198

1LT

BEGIN	3381	3381	3620	3354	3495	3401	3399	3411	3427	3543	3152	2958	3233
LOSSES	35	3	3	3	2	2	3	3	2	4	3	4	3
GAINS	1776	242	152	158	102		19	134	178	363	140	288	
PROM OUT	1906		415	14	194		4	115	60	750	331	9	14
END	3216	3620	3354	3495	3401	3399	3411	3427	3543	3152	2958	3233	3216

2LT

BEGIN	17335	17335	17433	17437	17385	17367	17262	17109	17139	17190	17455	17400	17487
TO REIMB													
LOSSES	1953	149	149	213	122	111	172	104	129	198	198	201	207
GAINS	1800	244	153	161	104	6	19	134	180	363	143	288	5
FROM W.O.	100									100			
PROM OUT	3824	148	540	154	304	129	146	226	174	902	629	243	229
PROM IN	3824	148	540	154	304	129	146	226	174	902	629	243	229
FROM REIMB	3	3											
END	17285	17433	17437	17385	17367	17262	17109	17139	17190	17455	17400	17487	17285

2LT - GEN



CWO-4

BEGIN	199	199	203	204	200	195	190	185	181	175	208	203	197
LOSSES	60	3	3	4	5	5	5	4	6	4	5	6	10
PROM IN	50	7	4							39			
TO LDO	2									2			
END	187	203	204	200	195	190	185	181	175	208	203	197	187

CWO-3

BEGIN	79	79	72	66	64	62	125	123	121	119	53	50	48
LOSSES	25		2	2	2	3	2	2	2	2	3	2	3
PROM OUT	50	7	4							39			
PROM IN	66					66							
TO LDO	25									25			
END	45	72	66	64	62	125	123	121	119	53	50	48	45
BEGIN	401	401	399	399	398	398	566	565	564	564	491	490	489
LOSSES	8	2		1			1	1	1	1	1	1	1
PROM OUT	66					66							
PROM IN	234					234				73			
TO LDO	73									491			
END	488	399	399	398	398	566	565	564	564	491	490	489	488

CWO-2

BEGIN	504	504	504	502	502	502	518	518	518	518	518	518	517
LOSSES	4		2									1	1
GAINS	250					250							
PROM OUT	234					234							
TO LDO													
END	516	504	502	502	502	518	518	518	518	518	518	517	516

WO-1

BEGIN	1183	1183	1178	1171	1164	1157	1399	1391	1384	1376	1270	1261	1251
LOSSES	97	5	7	7	7	8	8	7	8	6	9	10	15
GAINS	250					250							
PROM OUT	234					234							
TO LDO													
END	1183	1178	1171	1164	1157	1399	1391	1384	1376	1270	1261	1251	1236

TOTAL WARRANT OFFICERS

BEGIN	1183	1183	1178	1171	1164	1157	1399	1391	1384	1376	1270	1261	1251
LOSSES	97	5	7	7	7	8	8	7	8	6	9	10	15
GAINS	250					250							
TO LDO	100					300							
PROM OUT	350	7	4			300							
PROM IN	350	7	4			300							
END	1236	1178	1171	1164	1157	1399	1391	1384	1376	1270	1261	1251	1236



BEGIN	18518	18518	18611	18608	18549	18524	18661	18500	18523	18566	18725	18661	18738
TO REIMB													
LOSSES	2050	154	156	220	129	119	180	111	137	204	207	211	222
OFFICERS GAINS	2050	244	153	161	104	256	19	134	180	363	143	288	5

FROM REIMB	3	3											
END	18521	18611	18608	18549	18524	18661	18500	18523	18566	18725	18661	18738	18521

OFFICERS IN REIMBURSABLE BILLETS			
	COL	LCOL	CAPT
BEGIN	8	21	2
TO	0	0	0
FROM	1	1	0
END	7	20	2
CONTINUE? NO-			

## REFERENCES

- [1] Gilman, L. and Rose, A. J., APL: An Interactive Approach, J. Wiley, New York, 1974.
- [2] Grinold, R. C. and Marshall, K. T., Manpower Planning Models, Elsevier-North Holland, 1977.

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